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The lexical boost effect is not diagnostic of lexically-specific syntactic representations

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ABSTRACT

Structural priming implies that speakers/listeners unknowingly re-use syntactic structure over subsequent utterances. Previous research found that structural priming is reliably enhanced when lexical content is repeated (*lexical boost effect*). A widely held assumption is that structure-licensing heads enjoy a privileged role in lexically boosting structural priming. The present comprehension-to-production priming experiments investigated whether head-constituents (verbs) versus non-head constituents (argument nouns) contribute differently to boosting ditransitive structure priming in English. Experiment 1 showed that lexical boosts from repeated agent or recipient nouns (and to a lesser extent, repeated theme nouns) were comparable to those from repeated verbs. Experiments 2 and 3 found that increasing *numbers* of content words shared between primes and targets led to increasing magnitudes of structural priming (again, with no 'special' contribution of verb-repetition). We conclude that lexical boost effects are not diagnostic of lexically-specific syntactic representations, even though such representations are supported by other types of evidence.

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The lexical boost to structural priming

A well-documented psycholinguistic finding is that speakers tend to repeat aspects of syntactic structure from one utterance to the next (e.g., Bock, 1986; Bock & Loebell, 1990; Bock, Loebell, & Morey, 1992; Branigan, Pickering, & Cleland, 2000; Cleland & Pickering, 2003; Corley & Scheepers, 2002; Pickering & Branigan, 1998; for reviews and meta-analyses, see Pickering & Ferreira, 2008; Mahowald, James, Futrell, & Gibson, 2016). This finding has been reported for a wide range of syntactic alternations, including active/passive sentences (e.g., *one of the fans punched the referee* vs. *the referee was punched by one of the fans*), prepositional object (PO) versus double object (DO) ditransitive structures (e.g., *a rock climber sold some cocaine to an undercover agent* vs. *a rock climber sold an undercover agent some cocaine*), and noun modification using a pre-nominal adjective or a post-nominal relative clause (e.g., *the red sheep* vs. *the sheep that's red*), to name but a few. Critically, in each of these cases, at least two different syntactic structures are available to express the same message, and the speaker must choose between them. This choice is affected by the form of a previously encountered utterance: After using one type of structure in a 'prime' trial, people are more prone to use the same structure in a subsequent 'target' trial when faced with the same structural choice. This phenomenon is generally referred to as *syntactic priming* (or *structural priming*, respectively). It indicates that speakers or listeners must retain some form of abstract structural representation in memory once they produced or understood an utterance, which they can re-use during subsequent sentence formulation or comprehension.

Interestingly, while syntactic priming does not require the repetition of lexical content across utterances, it has been shown to be considerably enhanced by the latter. To give a classical example, Pickering and Branigan (1998; see also Corley & Scheepers, 2002) investigated ditransitive structure priming using a written sentence-completion task. They found that the tendency to re-use the (PO or DO) structure of a prime in a subsequent target trial was reliably stronger when the main verb was repeated between prime and target. Cleland and Pickering (2003) reported a similar effect for nouns. They had participants produce noun phrase descriptions such as *the red sheep* or *the sheep that's red*, and found that the tendency to repeat syntactic structure (pre-nominal adjective vs. post-nominal relative clause) was enhanced if the head noun (*sheep*) was repeated between prime and target.

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This so-called 'lexical boost' effect (enhanced structural priming in the context of shared lexical content between prime and target) has frequently been taken as evidence for lexicalized representations of structural knowledge, i.e., the idea that abstract syntactic representations are associated with the morphosyntactic properties of individual lexical items in long-term memory. For instance, Pickering and Branigan (1998) suggested an explanation of their own findings based on the inclusion of so-called combinatorial nodes into the lemma level of the production lexicon. In their account, individual lexical items (such as verbs) are associated with combinatorial nodes which encode the syntactic frames that are licensed by those items. For example, the lemma node for an alternating ditransitive verb such as *sell* is connected to a combinatorial node encoding a PO structure (e.g., [$_{VP}$ [$_{V}$ *sell*] [$_{NP}$ *an umbrella*] [$_{PP}$ *to a tourist*]]) as well as to another combinatorial node encoding a DO structure (e.g., [$_{VP}$ [$_{V}$ *sell*] [$_{NP}$ *a tourist*] [$_{NP}$ *an umbrella*]]). Each structural configuration is represented by a distinct combinatorial node linked to the verb, and each combinatorial node is shared with other verbs that can project the same structure. Use of *sell* with a PO construction (e.g., *a rock climber sold some cocaine to an undercover agent* would activate the lemma node for *sell* and also the PO combinatorial node, and their co-activation would lead to a strengthening of the connection between them. Assuming that activation patterns do not decay immediately, activation of the PO node would make it easier for the same PO node to reach activation threshold in a subsequent trial. Thus, when the speaker faces a ditransitive structure choice again, but involving another ditransitive verb such as *give*, he/she will be more likely to use the previously produced PO rather than the alternative DO structure. Since the combinatorial nodes are shared between different lemmas (e.g., *sell*, *give*, *send*, *show*, etc.), structural priming occurs even if subsequent trials do not employ the exact same verb. Importantly, however, if the critical verb lemma is repeated between one utterance and the next, then not only residual activation of the combinatorial node, but also residual activation of the *link between combinatorial node and lemma node* will create a bias towards re-using the relevant structure. This effectively explains the lexical boost effect, whereby structural priming is enhanced whenever subsequent utterances employ the same lemma (e.g., the verb *sell* in both prime and target trial).

In sum, Pickering and Branigan's (1998) argument is that residual activation of abstract structure (encoded in combinatorial nodes) and its connection with individual word lemmas are at the heart of syntactic priming, and more specifically, lexical boosts to such effects, which since then have been demonstrated cross-linguistically across a range of different constructions, paradigms, and processing modalities (e.g., Arai, van Gompel, & Scheepers, 2007; Branigan et al., 2000; Cleland & Pickering, 2003; Gries, 2005; Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008; Hartsuiker & Kolk, 1998; Hartsuiker & Westenberg, 2000; Pickering & Branigan, 1998; Segaert, Kempen, Petersson, & Hagoort, 2013; Traxler, 2015; Traxler, Tooley, & Pickering, 2014; see also Mahowald et al., 2016).

An important theoretical implication of Pickering and Branigan's (1998) model appears to be that sharing of uncritical *non-head* constituents between prime and target should not (or not as much) result in boosted syntactic priming. This is because it must be the licensing head of a phrase that is linked to the kind of combinatorial information envisaged in Pickering and Branigan's (1998) model. Indeed, PO and DO structures are grammatically licensed by ditransitive verbs, and not by argument nouns or other types of constituents. A special role of the verb is also suggested by recent findings showing that repetition of verb *senses* contributes to the lexical boost in ditransitive structure priming (Bernolet, Colleman, & Hartsuiker, 2014).

In contrast, Chang, Dell, and Bock (2006) proposed a very different account of the previous findings. According to their model, structural priming is not a reflection of short-term activation (and gradual decay) of syntactic representations that are shared between different word lemmas, but rather the result of *implicit learning*, i.e., gradual changes in the weights of (implicitly acquired) long-term associations representing abstract syntactic knowledge. Curiously, simulations based on a formal implementation of their model failed to replicate any lexical boost effects,[1] while otherwise being able to account for a variety of other findings related to syntactic priming. Chang et al. (2006) therefore conjectured that the lexical boost of syntactic priming may actually be distinct from structural priming *per se*: "*We hypothesize that lexical enhancement of priming is not due to the weight-change mechanisms that lead to long-lasting structural priming. Rather, they are due to explicit memory for the wording of the prime. When the target is being planned, the repeated content word serves as a cue to the memory of the prime and this biases the speaker to repeat its structure. This explicit memory component to priming is distinct from the model's weight-change mechanism.*" (p. 275). Interestingly, assuming that potentially *any* content word can act as retrieval cue to the wording of the prime, this hypothesis does not necessarily imply a special role of the verb in lexically boosting PO/DO priming.

These contrasting theoretical views motivate the following general question: While lexical boost effects are well established and robust, do phrasal heads (e.g., verbs in ditransitive verb phrases) play a more important role in boosting structural priming than non-head constituents? McLean, Pickering, and Branigan (2004) reported a series of PO/DO priming experiments that partially addressed this issue. Across experiments, they manipulated (a) the number of argument nouns repeated between primes and targets (all three [agent, recipient, and theme] vs. none) and (b) specific argument nouns (theme or recipient) repeated between primes and targets. Verbs were never repeated in their experiments. As for (a), McLean and colleagues found a massive structural priming effect (ca. 75%) when all three nouns were repeated as compared to when no lexical repetition occurred (ca. 37%). Interestingly, related to (b) they found a reliable lexical boost effect when only the theme or only the recipient noun was shared between prime and target. Although the report does not contain any statistical comparisons between experiments, the priming effect appeared stronger when the recipient noun was repeated than when the theme was repeated. With regards to our general question outlined above, these are highly relevant findings because they suggest that lexical boost effects are at least not *bound* to the licensing head of the ditransitive verb phrase: clear lexical boost effects on PO/DO priming can also be observed when only argument nouns (but not verbs) are shared between primes and targets. Still, one important aspect of our question remains unanswered, namely whether priming with repeated verbs is different from priming with repeated nouns. In other words, while lexical boost effects on syntactic priming are not restricted to repeating licensing heads, it is still possible that repeating the verb between prime and target will lexically boost PO/DO priming even more than repeating any of the argument nouns, given that the verb enjoys a special role in licensing PO/DO structures.

[1] Importantly, this does not mean that implicit learning accounts are incapable of modelling verb-related structural preferences. For example, Chang, Janciauskas, and Fitz (2012) and Twomey, Chang, and Ambridge (2014, 2016) have shown that such a model *can* acquire long-term associations between individual lexical items (e.g., verbs) and syntactic structures. However, this implicit learning process happens gradually and over relatively long periods of time, whereas the lexical boost effects we refer to in this paper are typically strong enough to be observable in the short term (see in particular Chang et al., 2012, p. 265). Also note that the issue of verb-related structural preferences is indeed *orthogonal* to whether or not the verb is shared between prime and target (cf. lexical boost).

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